Materials Bulletin: Alkali-Silica Reaction (ASR) Brief

What is ASR?
ASR is a reaction between the alkali hydroxides in concrete and reactive forms of silica in the aggregate. The reaction forms a gel that swells when moisture is present. The two step process can be visualized as:

1. Alkali + Silica → Gel reaction Product
2. Gel reaction Product + Moisture → Expansion

Factors Affecting ASR
For the reaction to occur the following three conditions must be present:

1. Sufficiently high alkali content of the cement
2. Reactive forms of silica in aggregate
3. Sufficient Moisture

If one of these three conditions is missing the reaction cannot occur.

Why is ASR Bad?
ASR can cause serious expansion and cracking in concrete. This can result in major structural problems, which can lead to costly removal and replacement. The reaction can become evident years after the concrete was placed. Structures most at risk are bridges, hydraulic structures, exposed frames, pavements, and foundations.

How does NC DOT Mitigate the Problem?
The best way to avoid ASR is to take appropriate precautions before the concrete is placed. Section 1024-1 of the NC DOT Standard Specifications for Roads and Structures addresses these precautions.

1. For concrete mix designs that contain an aggregate that has exhibited alkali-silica reactivity as documented by the Department, ensure that the alkali content of the cement, expressed as sodium-oxide equivalent (found on the certified mill report from the cement manufacturer), does not exceed 0.4%. However, cement with a higher alkali content not to exceed 1% is allowed if used with Class F fly ash, ground granulated blast furnace slag, microsilica, or other Department approved pozzolans in the amounts shown below.

2. For all other mix designs, ensure that the alkali content of the cement, expressed as sodium oxide equivalent (found on the certified mill report from the cement manufacturer), does not exceed 0.6%. However, cement with a higher alkali content not to exceed 1% is allowed if used with Class F fly Ash, ground granulated blast furnace slag, microsilica, or other Department approved pozzolans in the following amounts:

Class F Fly Ash	20% by weight of required cement content, with 1.2 lbs. Class F fly ash per lb. of cement replaced.
GGBF Slag	35% - 50% by weight of required cement content, with 1 lb. slag per lb. of cement replaced.
Microsilica	4-8% by weight of required cement content, with 1 lb. microsilica per lb. of cement replaced.

See the reverse for tabular information and notes regarding materials associated with ASR

Table 1: Aggregate Sources That Have Exhibited ASR as Documented by the Department

Owner	Location	Quarry Number
Hanson	Princeton	CA 64
Martin Marietta	Asheboro	CA 30
	Bakers	CA 32
	Pomona	CA 51
	Thomasville	CA 102
Vulcan	Gold Hill	CA 85

Table 2: Average Sodium Oxide Equivalent values of common cement sources used in North Carolina

Producer	Facility	Sodium Oxide Equiv.
Cementos, Argos	Cales, Tolucemento, Tolu, SA	0.52
	Cartagena, Colombia, SA (Colclinker)	0.36
	Cementos Del Caribe, Barranquilla, Colombia	0.51
Cemex (Dixie)	Knoxville, TN	0.53
	Medusa, Clinchfield, GA	0.34
Essroc	Speed, IN	0.55
Giant	Harleyville, SC	0.46
Holcim	Holly Hill, SC	0.47
	Holly Hill, SC (Slag Modified)	0.46
Lafarge	Atlanta, GA	0.42
	Harleyville, SC	0.48
	Ravena, NY	0.69
	Roberta Plant	0.39*
Lehigh	Union Bridge	0.58
Roanoke	Cloverdale, VA	0.75

Notes:

1. **Table 2 is color coded to denote cements that require pozzolan in the mix design to prevent potential ASR gel from forming in the final product.**

   Red designates pozzolan required
   Yellow designates pozzolan required when used with potentially reactive aggregate (See Table 1)
   Green designates no pozzolan required (See Note 2 below)

2. **Pozzolan is required for bridge decks in Divisions 5, 7, & 9-14. See the plan notes on General Drawings.**

* **Cement supplied from Lafarge's Roberta plant will be closely monitored by Materials and Tests due to its proximity to the 0.40 Sodium Oxide Equivalent threshold.**